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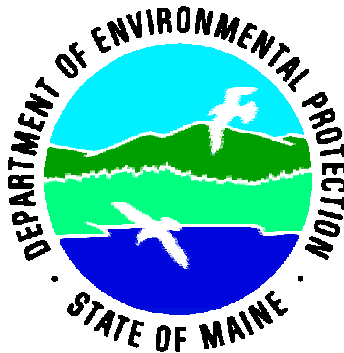
**Maine Department of Environmental Protection
NOAA Coastal Services Center
Maine Coastal Program, Maine State Planning Office
Maine Department of Marine Resources**

MAINE'S COASTAL WETLANDS:

I. TYPES, DISTRIBUTION, RANKINGS, FUNCTIONS AND VALUES

by

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SUMMARY

This two volume report addresses the need for reference material on coastal wetlands of Maine and the need for a standard wetland assessment method for intertidal wetlands used in the permitting process statewide.

Volume I, designed for reference by DEP project managers, review agencies and consultants, provides biological and geological information on Maine's coastal habitats (wetlands) and summarizes current development over the past five years within coastal wetlands in Maine. Detailed information on the types, acreage, and distribution of seven intertidal habitats is provided. Functions, values and management suggestions to reduce wetland damage and loss are furnished for seven intertidal habitats, three subtidal habitats and three vegetated habitats. Each summary contains a table of functions and values for quick reference. Intertidal habitats are ranked according to their productivity and sensitivity to development. A short summary on seasonal variability in marine environments is provided to assist in the review of biological data.

Volume II, written for professional consultants, provides recommended functional assessment guidelines that can satisfy the functional wetland assessment requirement in intertidal habitats for Natural Resources Protection Act (NRPA) applications. It includes suggested sampling approaches by permitted activity type and their associated impacts. The guidelines include both qualitative and quantitative protocols for intertidal habitats.

INTRODUCTION

Introduction

Anyone, who has flown, driven or sailed the entire coast of Maine, knows the incredible diversity of coastal environments along the coastline of Maine. Long stretches of sand beaches, expansive salt marshes, irregular rocky ledges, and vast mud flats are a few of the environments distributed along the approximately 5,300 miles of shoreline between Kittery and Calais.

Maine's coastal wetlands are one of the most important environments to the people of Maine. In fact, 540,000 people or 43 % of the population of Maine live in the 144 coastal towns of Maine that comprise only 12 % of the area of the state (Maine State Planning Office 1997). They are used by residents and non-residents for numerous recreational activities from fishing to sea kayaking. They support a multi-million dollar commercial and recreational lobster, clam and fishing industry. Coastal wetlands are the main attraction to outsiders and have become the single most important resource for the tourism and recreation industry in Maine (Colgan and Plumstead 1995).

Over the past several years commercial and private development pressures within the coastal wetlands of Maine have increased. Out of state residents, attracted by the natural beauty of Maine and affordable waterfront real estate (as compared to other New England states), purchase shorefront property and construct waterfront summer homes, piers, and docks. In addition, over eight million tourists and summer residents visit Maine annually with a majority of the people visiting coastal communities (Maine State Planning Office 1997).

As people relocate to and visit the desirable coastal communities, demands on the natural environment are inevitable. New structures built to accommodate increasing numbers of tourists and residents alter water quality, displace and/or shade habitats, increase disturbance, erosion and stormwater runoff and change circulation patterns. Coastal areas are continually threatened by increased commercial and private developments that alter, fill, dredge, impound, armor and shade marine environments.

As a result of population growth along the coast, applications for alterations and development are received daily by the DEP. Each project is reviewed for adverse impacts to the coastal wetland. The quality of information provided in the application determines the ease and speed of review and directly affects the outcome of the project.

Maintaining a balance between development and preservation is crucial to preserving the Maine lifestyle and promoting a prosperous economy. State environmental laws have been developed to reduce impacts to marine habitats while allowing growth and development.

Legal Basis for Protection

To protect the natural environment from adverse impact associated with development, the Natural Resources Protection Act (NRPA) (38 MRSA 480-A to 480-Z) including the Wetland Protection Rules (Chapter 310), and the Water Classification Act (38 MRSA, Section 465-B) were developed between 1988-1994 to prevent pollution, degradation, alteration, and habitat loss in tidal wetlands. Under these rules and statutes, the Maine Department of Environmental Protection (MDEP) is bound to restrict activities that will "unreasonably harm any significant wildlife habitat.....estuarine or marine fisheries or other aquatic life" (38 MRSA 480-D) or cause a net loss in the functions and values of coastal wetlands.

Coastal Wetlands: All tidal and sub-tidal areas, including all areas below any identifiable debris line left by tidal action; all areas with vegetation present that is tolerant of saltwater and occurs primarily in a salt water or estuarine habitat; and any swamps, marsh, bog, beach, flat, or other contiguous lowland which is subject to tidal action during the maximum spring tide level as identified in tide tables published by the National Ocean Service (38 MRSA 480-B).

Since the inception of the Natural Resources Protection Act in 1988, any person seeking to develop a site, repair a permanent structure or physically alter soils in, on or over a coastal wetland or within 100 feet of the coastline must first receive approval from the DEP. The applicant may file an individual NRPA permit or a Permit-by Rule (PBR) permit. Individual NRPA permits may require state and federal agency review and approval, mapping, site and project description, functional wetland assessment, alternatives analysis, and compensation plan. Permit-by Rule activities are routine activities that should not cause significant harm to the marine environment provided that the standards are followed and, therefore, do not require thorough departmental evaluation, wetland functional assessments or inter-agency review. Applicants simply file a one page DEP Permit-by-Rule notification form with a site location map and photographs of the existing conditions of the site. The application is reviewed by DEP staff and if the applicant meets Permit-by-Rule standards than the project can commence 14 days from the date of submission without additional notification or site visit by DEP personnel.

Larger projects that alter greater than 500 sq ft of coastal wetlands and, therefore, do not meet the PBR standards require wetland assessments from consultants hired by the applicant and project review comments from as many as seven different organizations. Assessments identify the functions and values of the wetland, estimate the impact and describe how to minimize the impact. Review comments are received by DEP from Maine Department of Marine Resources (DMR), Maine Department of Inland Fisheries and Wildlife (IF&W), Army Corp of Engineers (ACOE), the Maine Geological Survey (MGS) and Department of Conservation Submerged Lands. Additional comments from

National Marine Fisheries Service (NMFS), the US Fish and Wildlife Service (USF&WS), and the Environmental Protection Agency (EPA) are received and examined by the Army Corps of Engineers. Federal and state agency comments target commercial fisheries concerns, rare plant habitat, significant wildlife habitat, navigational conflicts, geological processes and other issues that may be affected by the proposed development and/or modification. All comments and functional assessments are reviewed and evaluated by DEP project managers before the decision is made to either grant or deny the permit.

Even though Maine has well intended environmental laws for the management of coastal wetlands, there are gaps in the review process that the laws don't address. First, there is no standard functional wetland assessment methodology for consultants to follow. DEP instead receives a variety of professional wetland functional and impact assessments. Assessments vary from site to site, region to region, and consultant to consultant. Due to the extreme variation in composition and content of the assessments, there is a need for standardization of the assessment method so all projects are evaluated with equal thoroughness statewide. Secondly, information on Maine's coastal wetland functions and values is not readily accessible to DEP project managers, enforcement staff, developers, consultants, and review agencies.

Report Objective

This two-volume document was developed, with the help of many biologists and geologists inside and outside the department, to improve standardization of the permit process, help to educate staff on coastal wetlands in Maine, and improve habitat protection. It is intended to help applicants submit projects in a manner consistent with the law as well as facilitate review by DEP and other state agencies. It should help standardize the assessment process across all DEP regions and reduce confusion for applicants, consultants and staff. It offers information on a variety of different types of marine habitats to enhance protection of all components of coastal ecosystems. New employees unfamiliar with the functions and values of different coastal habitats and assessment methods may find this a useful reference guide. In addition, as these new guidelines are used by consultants, the detailed summaries, maps and photographs may assist reviewers or eliminate the need for DMR regional biologists and DEP staff to conduct as many field visits to make recommendations and decisions.

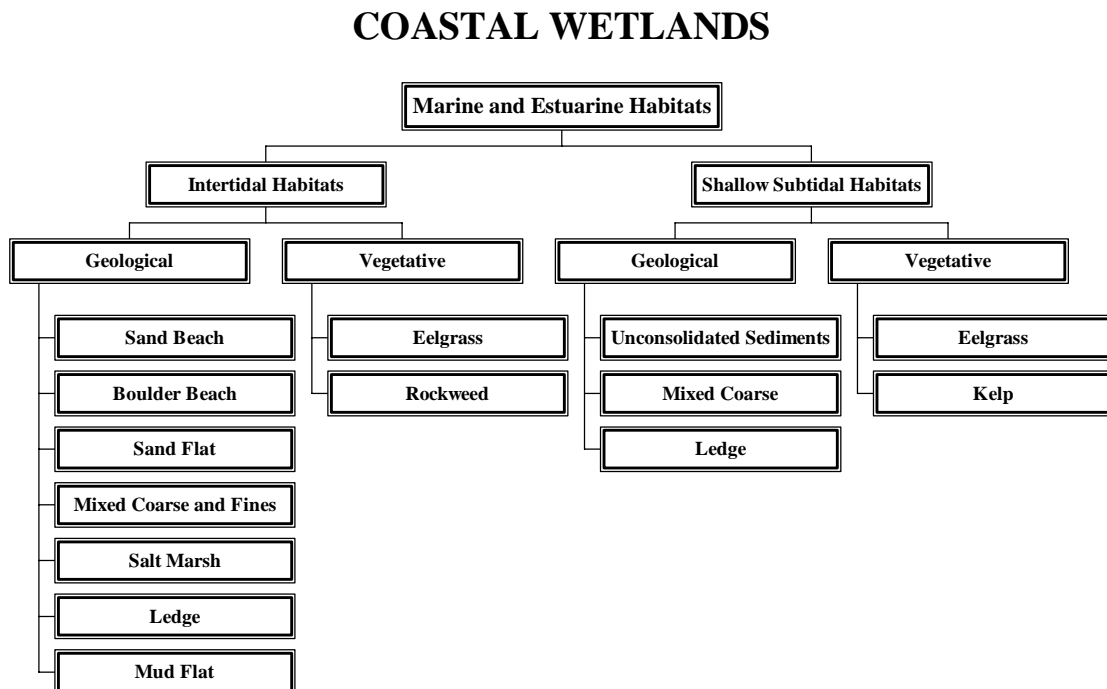
Volume I of this report, the educational component, was developed specifically for DEP permitting staff, but may also interest environmental consultants, state and federal review agencies as well as anyone interested in Maine's coastal environments. Volume II, which outlines the guidelines for functional assessment of intertidal coastal wetlands, was developed specifically for professional environmental consultants with a strong background in marine biology and taxonomy.

Classification of Marine Habitats

The classification of the habitat types within this report are based on the Classification System of Marine and Estuarine Habitats in Maine (Brown 1993) and the Classification

of Wetlands and Deepwater Habitats of the United States (Cowardin 1979). For simplification, only seven intertidal habitats, three subtidal habitats and three vegetated habitats are the focus of this report (see Figure 1 and Definitions). Acreage for the intertidal habitats was obtained from the digitized Coastal Marine Geologic Environment Maps (CMGE) created by Barry Timson in 1976 (see Appendix B for a discussion on the data analysis).

Figure 1.



DEFINITIONS

Marine: any seawater having a high salinity (~30 ppt or higher) that is not appreciably diluted by freshwater.

Estuarine: any seawater diluted with freshwater that has a salinity ranging between 0.5 ppt - 30 ppt.

Intertidal: area of coastal wetland between the high water line and the low water line that is exposed to the atmosphere at any time of the year.

Subtidal: area seaward of the lowest extent of the intertidal zone.

Intertidal Marine and Estuarine Habitats

Sand Beach: exposed environments containing at least 75 % sand.

Boulder Beach: exposed environments dominated by boulders.

Sand Flat: protected and semi-protected environments dominated by sandy sediment.

Mixed Coarse and Fines: semi-protected flats consisting of a mixture of rocks, boulders, gravel, sand, cobbles, and mud.

Salt Marsh: persistent nearshore emergent grass habitats.

Ledge: stable bedrock in protected and unprotected locations.

Mud Flat: protected environments containing at least 75 % mud.

Eelgrass: an annual and perennial vascular flowering plant located in low intertidal and shallow subtidal fine sediment marine and estuarine environments.

Rockweed: brown macro-algae (e.g. *Fucus* spp. and *Ascophyllum* spp.) that attach to intertidal hard substrates.

Shallow Marine and Estuarine Subtidal Habitats

Unconsolidated Sediments: submerged environments composed of fine clays, silt, mud, sand, gravel and organic matter.

Mixed Coarse: shallow submerged habitats comprised of larger rocks such as cobble and boulder.

Ledge: submerged stable bedrock in protected and unprotected locations.

Kelp: brown macro-algae (e.g. *Laminaria* spp., *Alaria* spp.) that attach to low intertidal and shallow subtidal hard substrates.

Citations: Classification System of Marine and Estuarine Habitats in Maine (Brown 1993).

Ecology and Management of Maine's Eelgrass, Rockweed and Kelps (Wippelhauser 1996)

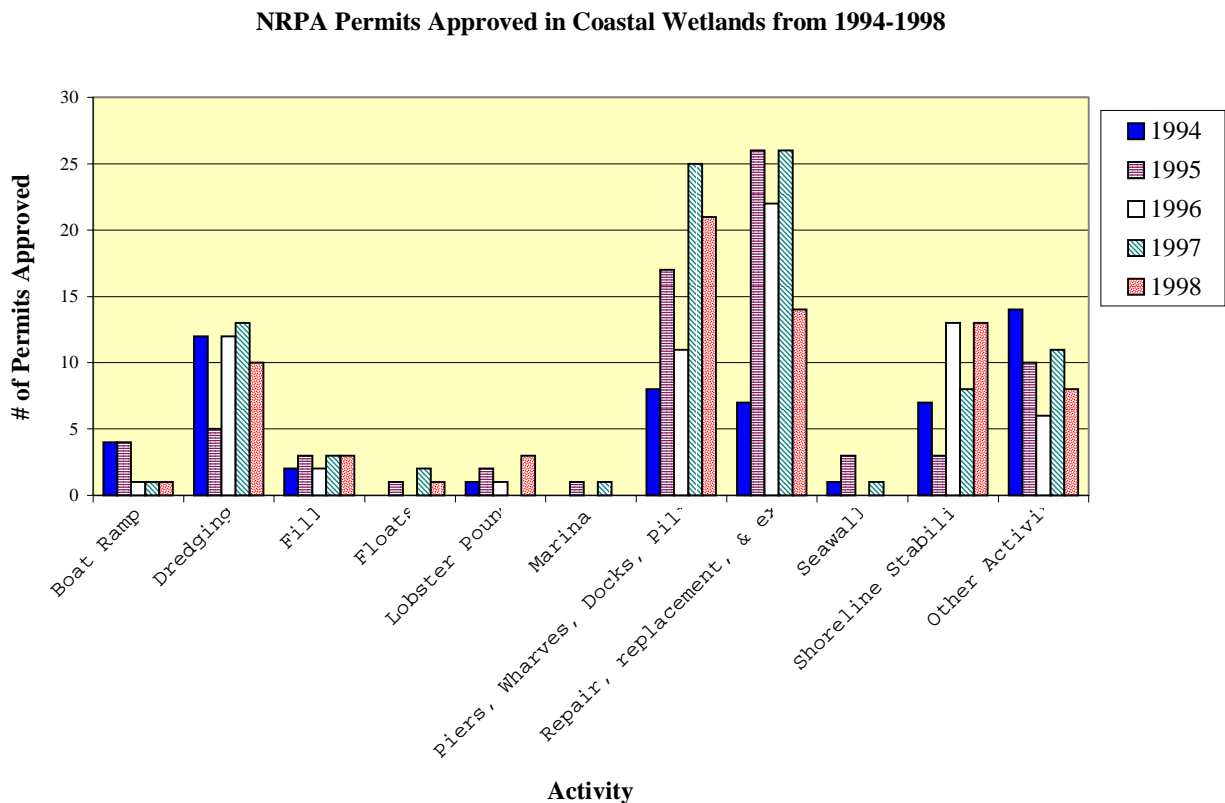
COASTAL DEVELOPMENT

NRPA Permitted Activity in Coastal Wetlands



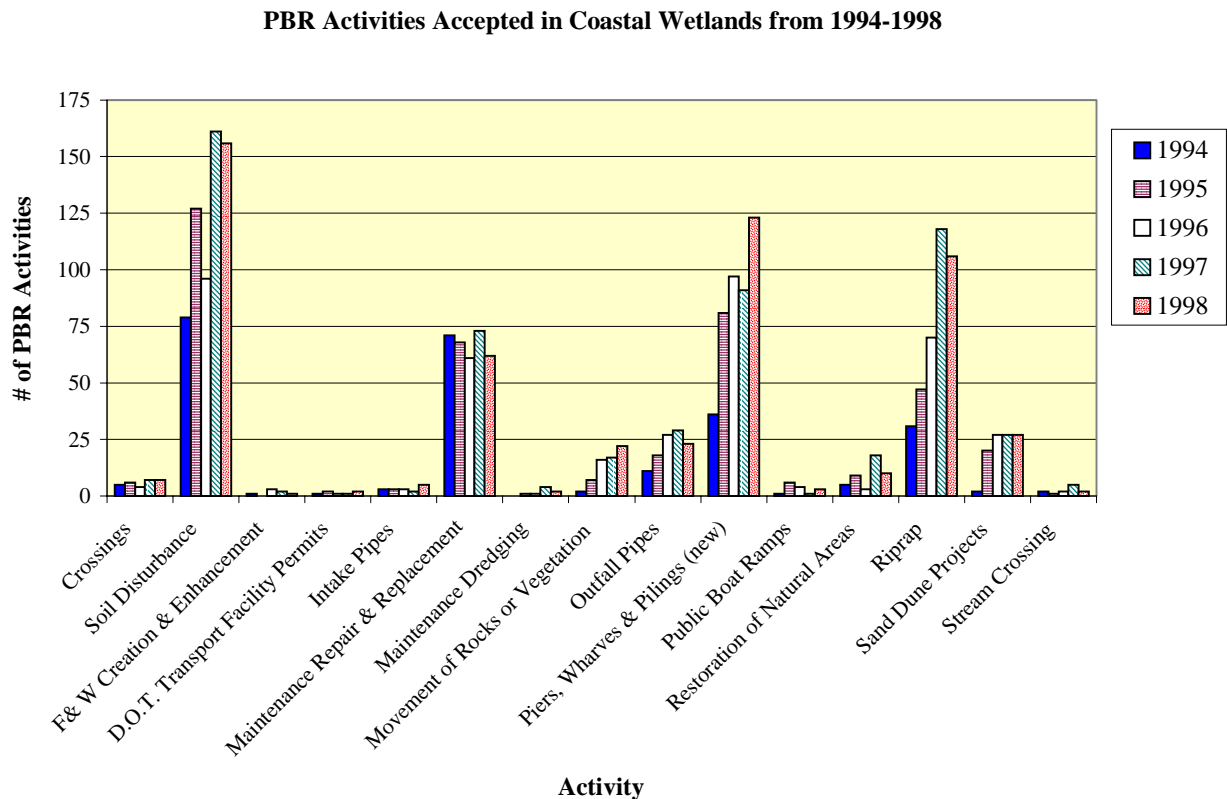
Between the years 1994-1998, 364 individual Natural Resources Protection Act (NRPA) permits were approved within the coastal zone of Maine (Figure 2). In addition to full NRPA permits, 2,168 NRPA Permit-by-Rule (PBR) activities (one Permit-by-Rule permit may have multiple activities) were authorized by DEP since 1994 (Figure 3, see Appendix A for definitions of Permit-by-Rule activities). In the last five years, some activities requiring a full NRPA permit have increased (e.g. piers, shoreline stabilization) while other activities remain about the same (e.g. dredging and fill) (Figure 2).

Figure 2.



Permit-by-Rule activities have increased in almost every category especially soil disturbance, riprap, and new piers, wharves, and pilings (Figure 3). There were 156 Permit-by-Rule permits accepted for soil disturbance and 123 permits accepted for new piers, wharves and pilings in 1998 compared to only 79 for soil disturbance and 36 for piers, wharves and pilings in 1994.

Figure 3.



Five hundred and ten new piers, wharves, and pilings have been approved since 1994. Out of the total, only 82 received full permit review by DEP staff and the rest were permitted under the rapid Permit-by-Rule process. Less than 16 % of the applications for piers required functional wetland assessment and interagency review. In addition, since 1994, as many as 335 of the old piers, docks and other structures in coastal wetlands have undergone repairs, replacement or extensions.

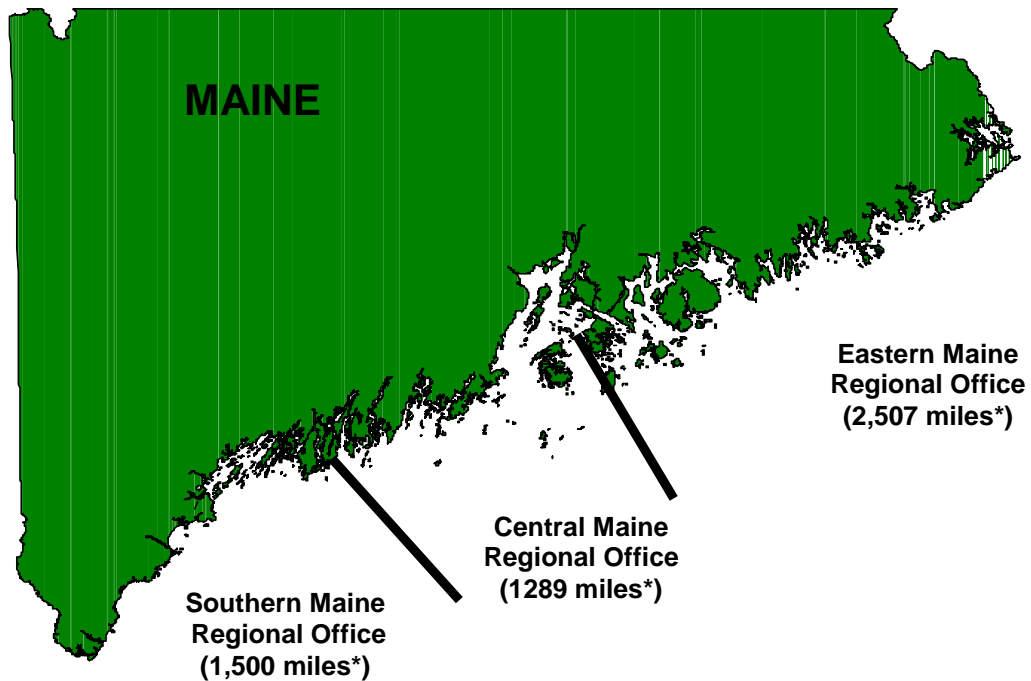
A total of 416 projects to stabilize the shoreline from erosion were licensed since 1994 but only 44 received full NRPA permit review. In other words, only 10 % of shoreline stabilization projects were required to have functional wetland assessments, impact assessments, and alternative analysis.

In summary, coastal development is on the rise and most of the activity statewide is permitted through the Permit-by-Rule process, a process that receives less review and oversight by all regulatory agencies. Since PBR seems to be the fastest growing form of applications, we hope that this Guide will better enable DEP managers and field staff to understand the cumulative impacts caused by PBR activities, consider the implications of amendment to PBR, be on the look out for legal PBR activities that may be causing unintended adverse harm, and equip staff with the basis for educating PBR customers on why certain restrictions exist.

NRPA Permitted Activity in Coastal Wetlands by Regional Office

In order to understand how development and workload differ throughout the coast of Maine, the approved NRPA permitted activities and accepted Permit-by-Rule activities were separated by DEP Region (Figure 4). An analysis of the total number of accepted permits between 1994 - 1998 by regional office confirms that development is on the rise in each coastal region of Maine (Figure 5).

Figure 4.

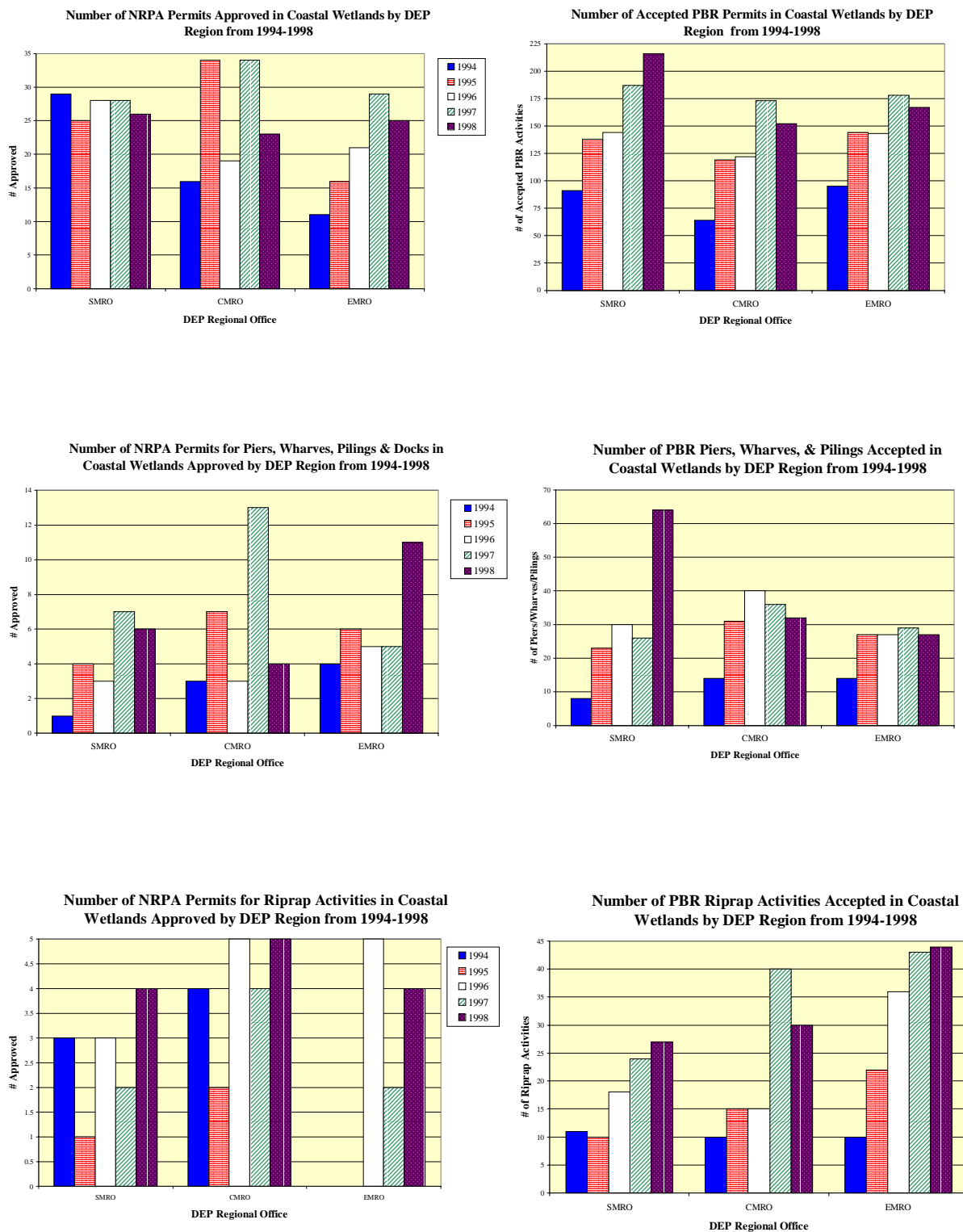


*Shoreline measurements of each region were estimated from 1:24,000 base maps provided by the ME Office of Geographic Information Services (OGIS).

Southern Maine Region

The Southern Maine Region, extending from Kittery to Georgetown, granted 912 permits between 1994 and 1998 amounting to the highest number of permitted activities coastwide. Southern Maine Region Office (SMRO) findings show a steady number of full NRPA permits over the past five years and a dramatic rise in Permit-by-Rule activity

Figure 5.



(Figure 5). SMRO granted 25 to 29 full NRPA permits in the coastal zone between 1994 and 1998. Permit-by-Rule activity rose from 91 to 216 permits granted during the same time period.

The amount of piers, wharves, and pilings and riprap activities clearly show a rise in activity in southern Maine even in full NRPA permits (Figure 5). A total of six full permits and 64 Permit-by-Rule permits were granted in 1998. This is approximately a 20% increase in pier activity. Riprap activities were more variable but also show a dramatic increase. A total of 31 permits, most through the Permit-by-Rule process, were granted in 1998 compared to only 14 in 1994.

Central Maine Region

The Central Maine Regional Office (CMRO), covering the shortest region in the state (1,289 miles) from Wiscasset to Vinalhaven, granted a smaller total number of NRPA permits and PBR permits between 1994 and 1998 than the Southern Maine Regional Office but a higher number of full permits for two years (Figure 5). Thirty-four full permits were granted in 1995 and 1997 compared to only 16 in 1994. As in southern Maine, central Maine had a rise in Permit-by-Rule activity ranging from 66 to 173 accepted applications.

The Central Maine Region had the highest total PBR activity for piers, wharves and pilings and the second highest riprap activity throughout the regions between 1994 and 1998 (Figure 5). One hundred and eighty three permits were approved for pier, wharves and pilings since 1994 with 30 requiring full NRPA review. Riprapping increased dramatically since 1994, often doubling or nearly tripling the previous years numbers of accepted activity.

Eastern Maine Region

Between 1994 and 1998, the Eastern Maine Regional Office had the second highest number of Permit-by-Rule activities coastwide, the lowest number of full NRPA permits accepted, and a steady continual increase in approved applications (Figures 5). The Eastern Region covers the greatest distance of coastline in the state (2,507 miles) from Isle of Haut to Calais and is the least populated coastal region. The levels of accepted activity along the northeast coast of Maine are now almost comparable to the numbers in the Southern Region, a smaller but more populated area of the state. Seven hundred and thirty-one Permit-by-Rule applications and 102 NRPA applications were approved over the recent five-year period. Over 40 % more applications were received and approved in the Eastern Region in 1998 than in 1994.

Between 1994 and 1998, coastwide, the Eastern Maine Region had the highest number of full NRPA permits approved for piers, wharves and pilings and the highest number of riprapping accepted through the Permit-by-Rule process (Figures 5). Four times as many PBR permits for riprapping were accepted in 1997 and 1998 than in 1994.

Coastal Wetland Impact

Virtually all permitted activities statewide have some type of environmental impact, some more serious than others. In implementing the law, we attempt to identify and distinguish activities causing "unreasonable harm" and "net loss in functions and values".

The following is a list of different types of impacts and examples of each impact that should be considered during review of any proposed project.

Direct Impacts

A direct impact is an impact that will affect or alter a well defined area of wetland. Direct impacts are the "footprint" of the activity. Direct impacts can be caused by filling, dredging, dragging, riprapping, damming, covering, impounding, scraping or other physical activities.

Indirect Impacts

An indirect impact is caused by an activity that alters the surrounding area through associated use or change caused by a direct activity. This impact is in addition to the direct impact and should be considered in the application review process.

Indirect impacts can affect water quality, movement of water and sediment and surrounding environments. Boating activity around wharves and marinas may cause permanent indirect impacts at the site by scouring eelgrass and algal communities, shading plants, polluting waters, and increasing erosion by the creation of wakes. The use of CCA pressure treated lumber has the potential to alter animal communities within a one meter radius of the placement of the treated wood (Lee Doggett, personnel comm.). The placement of a seawall can change wave direction, wave energy and the movement of sediment causing further erosion at the base of the seawall and erosion farther along the shore (Kelley et al. 1989). The placement of dams, causeways or culverts can cause indirect impacts by flooding or restricting water flows to adjacent areas. Riprapping an unstable bluff may slow erosion but may also cutoff sources of mud and sand required to nourish and maintain healthy mud flats and beaches (Kelley et al. 1989).

Temporary Impacts

Temporary impacts are impacts that conceivably last less than a few years. Many activities such as small dredging projects or placement of cable lines may have temporary impacts. Activities with temporary impacts do not change sediment type and the animal communities are likely to be restored to pre-disturbance levels within months to a few years.

Long Term Impacts

Long-term impacts cause a permanent change in the coastal wetland. Permanent changes can be caused by filling or removing habitat, changing habitat type, altering circulation

patterns by the placement of large structures, causing chronic erosion, increasing stormwater run-off or toxic contamination, increasing disturbance from humans and pets, and other everlasting alterations in the natural environment.

Positive Impacts

Not all projects have to result in negative impacts. Some activities that restore the natural environment can have positive results. Removal of sawdust accumulations, toxic sediments, invasive species or old rotting structures restores habitats to preexisting conditions. Stabilizing streams by adding vegetative buffers can enhance and restore aquatic life. Restoring tidal flows to ditched salt marshes reestablishes native plant and insect populations returning critical habitats to endangered species and waterfowl.

Multiple Impacts

Many, if not most activities, cause multiple direct and indirect impacts. These activities may physically dredge, fill, cover, or scrape coastal wetlands as well as indirectly change water quality, restrict sediment movement or cause other damage to marine environments.

A good example of an activity that has multiple impacts to coastal wetlands in Maine is lobster pounds. Even though the number of new projects is low in comparison with other activities (Figure 1), the total area of impact of coastal wetlands is generally large and therefore requires a full NRPA permit. Lobster pounds are used to hold lobsters in the marine environment during the fall and winter months until the value of the fishery increases and an optimal price per pound can be guaranteed.



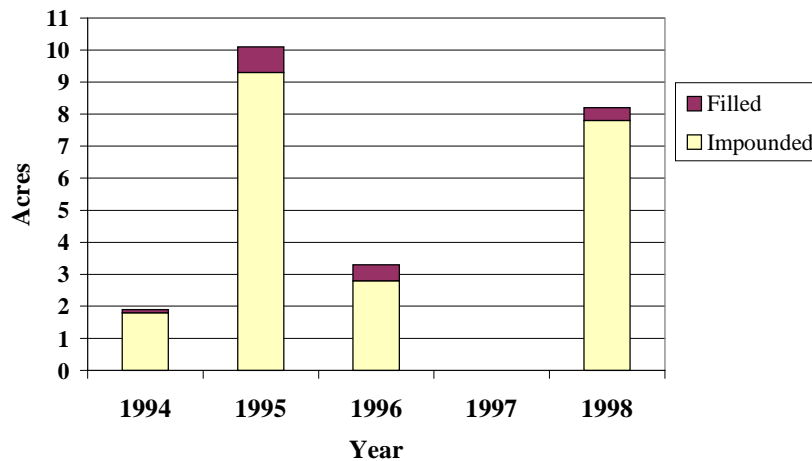
Seven acre lobster pound, Beals Island, ME

Since 1994, 23 acres of intertidal habitat have been impounded or filled for lobster pounds in Washington County (Figure 6). All pounds were constructed on intertidal fine sediments often characterized as having fringing salt marsh, annual eelgrass, rockweed, and commercially important species of soft-shelled clams, blue mussels, sandworms and bloodworms. For practical reasons, most lobster pounds are located within low energy environments such as mud flats in small bays and coves. A few are located on more exposed intertidal flats and a semi-circular or square berm or wall made from fill and

rock is constructed extending off the land and out into the intertidal zone to trap water (e.g direct impact).

Figure 6.

Total Amount of Intertidal Habitat Impounded or Filled for Lobster Pounds in Maine from 1994-1998



Seawater is usually impounded (indirect impact) from September to April, changing an intertidal mud flat to a subtidal impoundment. As the tides change, seawater flows over the top of the impoundment adding new sources of salt water and removing fresh stormwater run-off. Thousands of pounds of banded lobsters are impounded (as many as 60,000 lbs. / 2 acres), fed, and, in some pounds, treated with antibiotics for several months. Sides of the pounds are steeply sloped and short wire mesh fencing is constructed to keep lobsters from crawling out of the impoundment. Most pounds contain surface or bottom aeration that indicates there is low dissolved oxygen in the water (indirect impact). Turbid conditions are maintained within the pound by the constant digging by the lobsters. Lobsters are harvested from the pounds by dragging and hand-picking by divers. In April, pounds are drained, cleaned and smoothed by rakes and bulldozers. Most are open to intertidal clamming and worming by recreational and commercial fisherman during the draw-down period. As time goes by, sediments hardened as fine sediments are removed by lobster activity, pound maintenance and water exchange. These actions and results all impact the former mud flats and may violate state water quality laws (Lee Doggett, personal communication)

TYPES & DISTRIBUTION OF INTERTIDAL HABITATS

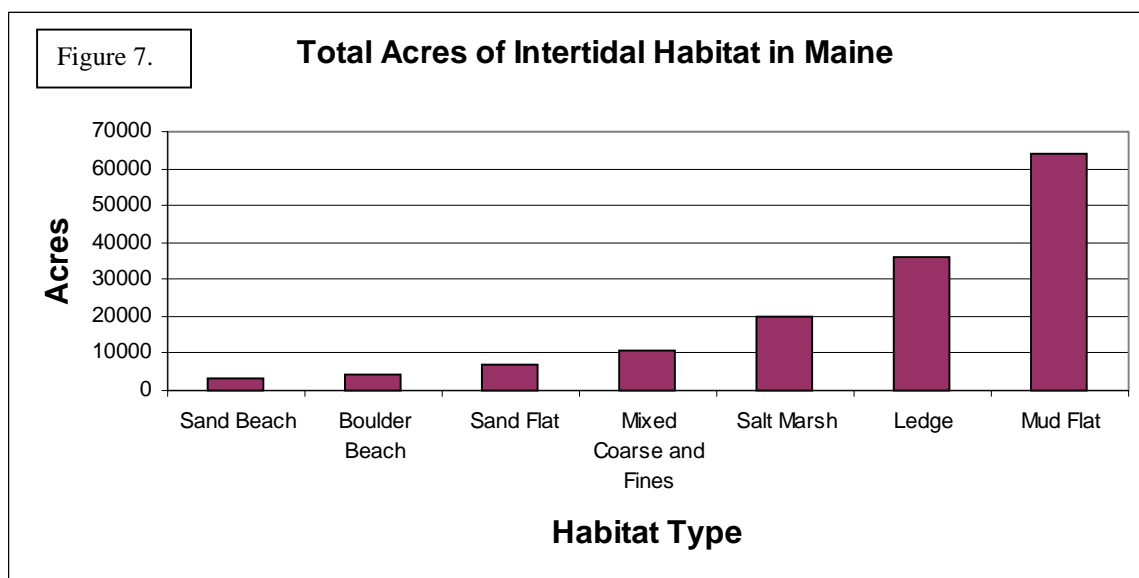
Types and Acreage of Intertidal Habitats

The Maine coastal landscape has a unique and diverse geological setting compared to other East Coast states. These geological formations are important in that they create the foundation of intertidal ecosystems that structure biological communities and form the base for commercial and recreational opportunities for Mainers (see next section). The length of the tidally influenced coastline of Maine measures approximately 5,300 miles (measurement estimated from 1:24,000 base maps provided by ME Office of Geographic Information Services). Its geological makeup is a complex mixture of bedrock headlands, rocky and sandy shores, barrier islands, barrier beaches, boulder fields, mud flats, and salt marshes. These geological features are partly a result of the advance and retreat of the Laurentide ice sheet accompanied by the drowning of the sea-coast during glacial times along with numerous other geological processes (Kelley et al. 1989). The Laurentide glaciation event spread over Maine to Georges Bank and only ended roughly 14,000 years ago on the coast. The advance and retreat of the glacier scoured the coastline of Maine, leaving behind ice-eroded rocky cliffs and substantial marine sedimentary deposits of gravel, sand and mud. The Presumpscot Formation, a glacial deposit of marine mud, sea-shells and drop-stones, prominent along the coast, was formed during this ice age (Kelley et al. 1989). Due to contemporary rising in sea level, bluffs of Presumpscot Formation currently erode along the Maine coast supplying coastal marshes, beaches and intertidal flats with new sources of muddy sediment (Fefer et al. 1980).

Although wave erosion of glacial deposits contributes the majority of new sediments to intertidal flats and beaches, additional sources of sediment are gained from rivers. In the spring, heavy rains and snowmelt flush river basins. Large volumes of water from the Kennebec and the Saco Rivers transport sandy glacial deposits onto mid-coast and southern beaches of Maine. Only these two rivers in Maine deliver large quantities of sand to the coast. Smaller rivers, such as the Penobscot, Royal and St. Croix Rivers, deliver muddy plumes of freshwater during spring and fall flood events into the Gulf of Maine (Kelley and Kelley 1995).

Daily intertidal and subtidal sediments are reworked by winds, waves, currents and tides. In bays and coves, sheltered from strong waves and currents, tides bring fine sediments into protected mud and sand flats. At high energy sand beaches in the late spring, summer and fall, wind driven circulation slowly bring sand and broken shells onto the beaches and sand dunes. During winter storms, sands are removed from the beaches and dunes and moved landward onto salt marsh (Kelley and Kelley 1995) or seaward. Off-shore deposits are formed in the winter, markedly altering the shape of the beach. Longshore transport currents, carry sands along the coast reworking the structure of the shore. For example, longshore currents create sand spits that extend offshore as well as transport sands inland filling the mouths of river channels (Kelley et al. 1995). This dynamic shifting of sands on high energy beaches create an unstable habitat for benthic marine life and, therefore, only adaptive species live in this environment.

There are a total of 145,069 acres of intertidal habitats in Maine (Figure 7, Table 1) (see Appendix B for data analysis). Mud flats are the most common and widely distributed intertidal habitat. Forty-four percent of all intertidal habitats are mud flats. Rocky headlands are the second most common geological feature along the shore. The bedrock headlands consist of granitic and metamorphic rocks created from ancient continental collisions (Kelley et al. 1989). Twenty-five percent of the shoreline of Maine is ledge. Off-shore islands contribute significantly to the total ledge acreage in Maine (Table 1). Correspondingly, there are 19,349 acres of tidally influenced salt marshes on the mainland and only 429 acres of emergent vegetated salt marsh on the offshore islands. Gravel beaches, coarse-grained flats, and mixed sand and gravel beaches are characteristic of mixed-coarse and fine flats that comprise 7 % on the intertidal shores.



Sand beaches, boulder beaches and sand flats are rare constituents of the intertidal zone in Maine. Only two percent of the total acreage of intertidal geology is sand beach. Sand flats are tidal flats composed of small sand grains slightly larger than the clay and fine sand sediments that characterize mud flats. They comprise only 5 % of the Maine shoreline. Boulder beaches, beaches that are dominated by boulders larger than 10" in diameter, make up only 3 % of the intertidal shore coastwide. Twenty-six percent of the total acreage of boulder beaches is located on offshore islands.

Table 1. Total acreage of intertidal habitats in Maine.

	Sand Beach	Boulder	Sand Flat	Mixed Coarse & Fine	Salt Marsh	Ledge	Mud Flat	Total
Mainland	2,719	3,035	6,744	8,400	19,349	26,839	61,169	128,255
Island	244	1,115	359	2,130	429	9,404	3,134	16,814
Total	2,963	4,150	7,102	10,530	19,778	36,243	64,302	145,069

Regional Distribution and Acreage of Intertidal Habitats

These diverse intertidal habitats are not distributed equally along the coast (Figure 8 & 9, Table 2). To help illustrate the spatial heterogeneity of Maine's coastal habitats, the state has been divided into four broad physiographic subsections, based on the distribution and nature of bedrock formations and glacial sediment supply (see Kelley 1987). For the complete list of habitat acreage by topographic quadrangle and regional groupings see Appendix B Table 3.

Table 2. Total acreage of intertidal environments in Maine by region.

Region	Sand Beach	Boulder	Sand Flat	Mixed Coarse & Fine	Salt Marsh	Ledge	Mud Flat	Total
Southwest (SW)	1,205	153	1,114	531	6,626	1,418	2,311	13,340
South Central (SC)	717	319	2,091	1,864	6,866	10,498	23,637	45,992
North Central (NW)	907	3,042	2,708	7,202	5,485	21,025	32,150	72,518
Northeast (NE)	134	636	1,190	951	800	3,302	6,205	13,219

Figure 8

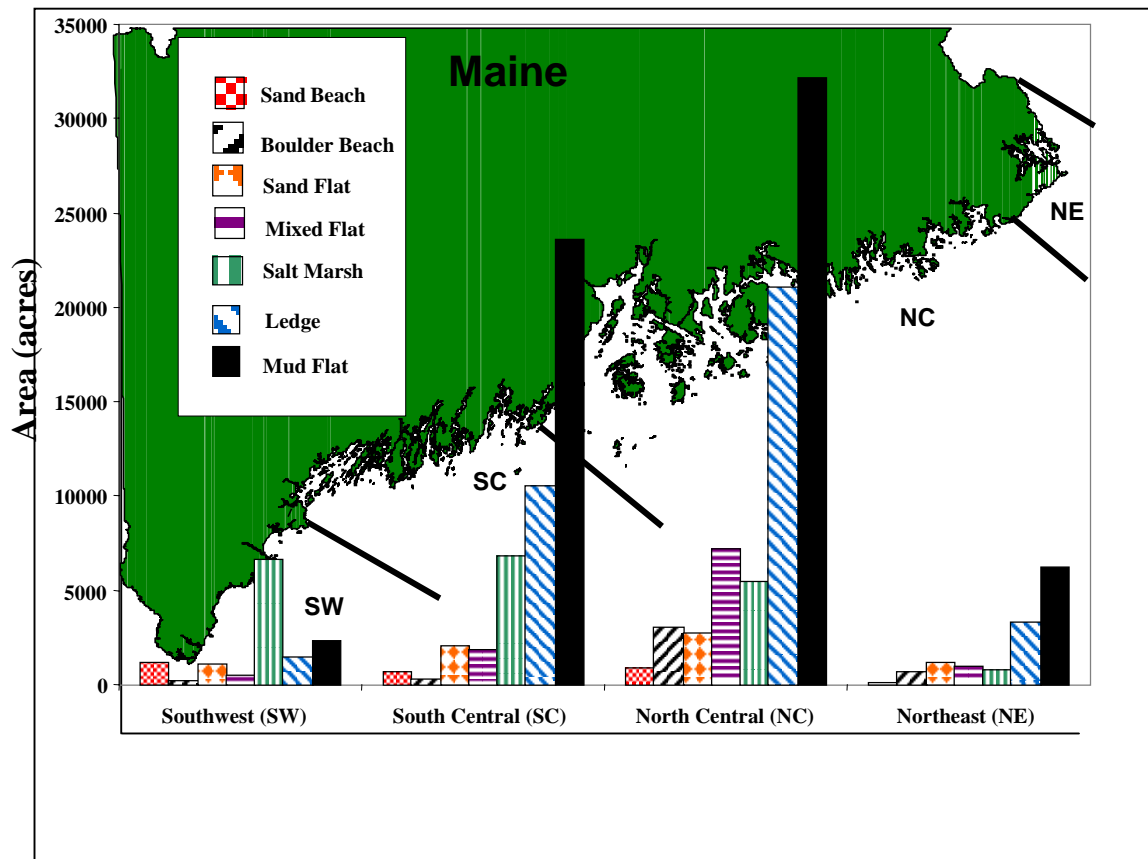
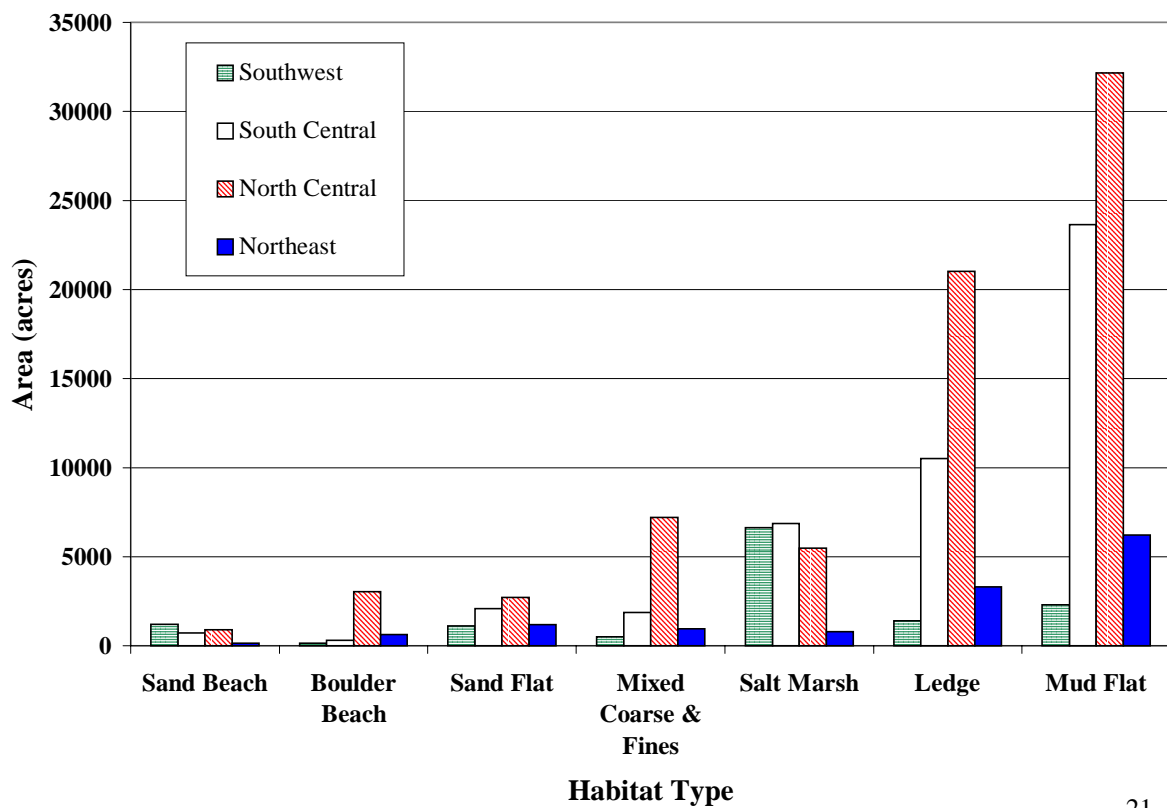


Figure 9



The southwest portion of the shoreline, from Kittery to Cape Elizabeth contains less than 8 % of the total acreage of intertidal environments in Maine. It is dominated by lush expanses of high salt marsh, barrier sand beaches, sand dunes and protective bluff headlands (Jacobson et al. 1987). Portions of the fine sediments that create the beach and marsh habitat are a result of slow erosion of the Presumpscot Formation (Jacobson et al. 1987). Over 40 % of the sand beaches and 34 % of the salt marshes in Maine are located south of Casco Bay. Unlike any other region in the state, this area is dominated by salt marshes. Fifty percent of the intertidal area in the southwest is high salt marsh. Sand beaches, supplied by the Saco River sediments, and salt marshes, characteristic of the region, are both located in Saco Bay between the sheltering rocky headlands of Prouts Neck and Biddeford Pool. In contrast to sand beaches and marshes, only 3.6 % of the total acreage of mud flat and 4 % of ledge statewide are south of Cape Elizabeth.

The South Central shoreline, also known as the "indented shoreline compartment" (Kelley et al. 1989) extends from Cape Elizabeth to Port Clyde. It is a region of large bays (e.g. Casco Bay), inlets, broad flats, bedrock peninsulas, and numerous small islands and estuaries. The Kennebec, Sheepscot, Damariscotta, and Medomak Rivers are a few of the larger rivers that drain the upland and bring new sources of muddy sediment to the tidal flats of the upper estuaries. The total area of intertidal habitat in the South Central Region is 45,992 acres, representing 32 % of the total intertidal area in Maine.

Unconsolidated sediment flats, ledges and salt marsh are the prominent geological features within the South Central Region. Thirty seven percent of all mud flats in Maine are located here. Flats in Maquoit Bay, Middle Bay, Quahog Bay, Broad Cove, Sheepscot Bay and Muscongus Bay contribute to the majority of the mud flat area. Sand flats, like the broad sand flat of Sagadahoc Bay in Georgetown, constitute 4.5 % of intertidal habitat in this section. High salt marsh, like the extensive marshes surrounding Casco Bay and Popham Beach, account for 35 % of the tidal marshes statewide. Much of the sediments on the marshes in this region are derived from the erosion of the Presumpscot Formation (Jacobsen et al. 1987) and river sediments (Kelley et al. 1989). Bedrock peninsulas protect intertidal marshes and flats and slow wave energy from the Gulf of Maine. Bedrock ledges account for 23 % of the South Central shores.

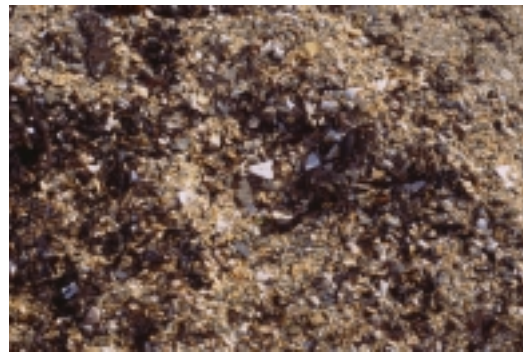
Sand beaches in the South Central Region account for 24 % of the area of beaches statewide but only constitute 1.5 % of the total amount of intertidal area in this region. A majority of this area is composed of sandy spits located at the mouth of the Kennebec River. Beaches like Popham Beach and Sewell Beach in Phippsburg and Reid State Park in Georgetown are three of the few publicly accessible sand beaches of the mid-coast area. The drainage of the Kennebec River supplies new sources of sands to these beaches and spits.

The North Central Region, also known as the "island-bay complex" (Kelley et al. 1989) is the largest compartment extending from Port Clyde to Machias Bay. It contains 72,518 acres of intertidal shores. The coastline is dominated by a mixture of large irregular bays (e.g. Penobscot Bay, Frenchman Bay, Machias Bay), expansive mud flats, rocky cliffs, fringing low salt marsh, and large islands (e.g., Mt. Desert Island, Deer Isle, Vinalhaven).

Most sediment, in this region, is supplied from upland erosion of metamorphic rocks (Kelley et al. 1995). The outer granite ledges and islands are subject to a high degree of direct wave exposure from the Gulf of Maine and are not prone to weathering.

The North Central Region contains the greatest area, statewide, of ledge, mud flat, mixed coarse and fine flats, boulder beaches, and sand flats. The tidal range, the distance between the low and high tidal levels, is a principal factor that accounts for the increase in area of intertidal northern shores (Maine State Planning Office 1983). Tidal range in the North Central Region ranges from 9-14 feet while in the southwest it ranges between 7-9 feet (Kelley 1987). Half of all the mud flats in Maine are located in the North Central Region. Vast expanses of mud flats at Harrington, Addison and Machias Bay contribute to the total of 32,150 acres. Due, in part, to the rocky embankments surrounding the large islands, ledge in the region accounts for 58 % of the total acreage of rocky shores in Maine. Sixty-eight percent of all mixed unconsolidated flats are located here. These deposits are located in less exposed regions.

Although very small in proportion to the other habitats (4 %) in the North Central Region, 3,042 acres of boulder ramps and beaches account for 73 % of all boulder fields in Maine. The largest deposits are located in the Rockland, Brooklin, Barlett Island and Swan Island quadrangles. These deposits are located in highly exposed sites and undergo constant weathering. New additions to boulder fields, like the boulder beach at Monument Cove, Acadia National Park, are currently being added from the wave erosion of granite cliffs (Kelley and Kelley 1995).



Monument Cove, Acadia National Park, Mt. Desert. Sand Beach, Acadia National Park, Mt. Desert.

Sand beaches and salt marshes only account for 1 % of the intertidal environments in the North Central compartment. Due to the limited sediment supply and other physical characteristics, only small patches of fringing marsh survive along protected river basins and bays (Jacobson et al. 1987). These low-marsh patches are dominated by *Spartina alterniflora* instead of *Spartina patens* and *Juncus gerardi*, two grasses typically representative of high salt marshes (Jacobson et al. 1987). The only major deposits of sand beach along the northern coast are located near Owls Head in the Rockland quadrangle (154 acres) and Roque Island and Sandy River Beach in the Jonesport quadrangle (184 acres). A small popular beach (<6.5 acres) at Acadia National Park on the eastern edge of Mt. Desert Island, is composed of broken shell fragments and sea

urchins spines unlike the sand beaches of the south (Kelley et al. 1989). This beach, and other small eastern island beaches, are composed of broken shells from blue mussels, periwinkles, clams, barnacles, urchins and other hard-shelled invertebrates (see photo) (Kelley and Kelley 1995).

The Northeast Region, or "cliffed shoreline compartment" (Kelley et al. 1989), runs from Machias Bay to Calais. It is only a few hundred miles in length (Kelley 1987) and has the smallest area of intertidal habitat. However, it has the greatest tidal range of any region ranging from 14-21 feet creating thousands of acres of intertidal shores (13,219 intertidal acres). Major portions of the shoreline are created from high volcanic cliffs and plutonic rock (Kelley 1987). The region only supports low fringing marsh in restricted protected coves (Jacobson et al. 1987).

Widespread unconsolidated flats and rocky cliffs dominate the eastern shores. Forty-seven percent of the coastal landscape is mud flat. The flats with the greatest acreage of habitat are located in Cobscook Bay surrounding Pembroke, Eastport and West Lubec. The largest mud flats are situated in Broad Cove (70 acres) and Carryingplace Cove (40 acres) in Eastport. The eastern flats characteristically become covered with a green filamentous algae known as *Enteromorpha intestinalis* each spring (Vadas and Beal 1987). Bedrock is the second dominant feature along the intertidal shoreline. The 3,302 acres of ledge act as a breaker of wind-generated waves from the bay and thus protect the estuarine habitats from erosion. Sand flats account for 9 % of the intertidal eastern shores and mixed coarse and fine beaches comprise 7 %.



Mud flat covered with *Enteromorpha intestinalis*, Eastport, ME

The Northeast Region has the smallest percentage of salt marshes and fine sand beaches in the entire state of Maine. There are only 134 acres of sand beach in the eastern section accounting for only 5 % of the sand beaches in Maine. The major deposits of sand beach, sand spits and swash bars are in the St. Croix River estuary and South Lubec. An unusual eroding glacial deposit of sand beach totaling nine acres in area is located on Dudley Island in Johnson Bay, Lubec. Only 800 acres of the fringing low salt marsh exist in the far eastern portion of the state, a mere 4 % of the tidal marsh statewide.

Significance of the Geology to Management

In summary, Maine's coastline has a great diversity of habitats but is only dominated by a few. Mud flats and ledge are the most common intertidal habitats, creating almost 70 % of the shoreline in Maine. A majority of the ledge and mud flats in Maine exist east of Cape Elizabeth. Sand beaches are the smallest constituent of intertidal geology in Maine. Almost all the sand beaches and emergent salt marshes lie in the south. Only small pocket beaches and fringing salt marshes exist Downeast due to the limitation of sources of sediment. Boulder beaches are also rare geological features in Maine. Most of the boulder beaches lie between Port Clyde and Machias Bay on unprotected off-shore islands. Sand flats only create 5 % of the Maine shoreline and are distributed throughout the state. Mixed coarse and fine flats make-up the rest of the coastline of Maine (7 %) and are concentrated on the shores of the irregular bays of the mid and east coast regions.

This information on the types and distribution of intertidal habitats is a foundation of data that provides the "big picture" of coastal geology. It should help in relating individual projects to the whole coastal and regional landscape. It provides information on which habitats are scarce or more plentiful statewide and by region. However, I do not advocate the misconception that less or more equals greater or lesser value and, therefore, should receive more or less protection. Instead, each site needs to be looked at individually from a functional point of view before any determinations can be made. From a biological perspective, the geology is the base and different environments have multiple levels of biological value (see next section). Even the same type of environment, doesn't always translate into the same biological importance statewide. For instance, some sand beaches in the south may have richer biological communities than sand beaches Downeast. This can be caused by geographical location, exposure, substrate, and numerous other factors (see introduction of next section). This is why general knowledge is not always enough, and site visits are necessary to determine habitat value.

**FUNCTIONS, VALUES AND
RANKINGS OF INTERTIDAL AND
SHALLOW SUBTIDAL HABITATS**

Introduction

For sound management, it is essential to clearly understand the biological differences and complexities of every intertidal and subtidal habitat subject to development. The following chapter addresses a series of questions about each major habitat type, and three vegetated habitats (eelgrass, rockweed, and kelp) and three shallow subtidal habitats (ledge, mixed coarse and unconsolidated sediments) not previously addressed. This section also lists the current threats to each habitat and provides a few suggestions for their future management. In addition, it includes a short section on the seasonal changes that can be expected within coastal marine habitats. This may be useful to assess the full potential of these habitats during the "off" season when species are dormant or absent.

The geological features of the coast, the physical and chemical characteristics of the seawater and the length of exposure to the sea, all influence the distribution of intertidal and subtidal marine plants and animals and the productivity of the site. The characteristics of the biological community are influenced by the physical location of the sediment or bedrock, geological features and texture of the substrate, wave and tidal energy, currents, light, water circulation, storm events, fresh water inputs, water temperature, salinity, predation, competition, ice and sand scour, over-fishing, disease, infections by bacteria and fungi, smothering by blooms of epiphytes and epifauna, availability of dissolved nutrients, and other biological, chemical and physical interactions. The species composition of soft bottom sediments is also influenced by organic content, water content, grain size, compaction, physical disturbance and oxygen penetration. Stable substrates, like bedrock, have a different species composition and density of animals than unstable shifting sediments. High intertidal regions favor organisms adapted to high exposure to air, wind, sun and fresh water. Subtidal species are less resistant and can not tolerate desiccation. Due, in part, to the decrease in length of time of exposure to atmospheric conditions, the diversity of marine fauna and flora increases as one approaches the subtidal. Distribution of subtidal species depends on the depth of the substrate and light penetration through the sea water. Due to biogeography, southwest intertidal and subtidal communities in Maine may have different assemblages of animals and algae than equivalent eastern communities (Mathieson et al. 1991). It should be clear that the variables driving or affecting intertidal and subtidal biota are many and complex.

